Art. XVI.—*The Highlands and Main Divide of Western Victoria.*

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(With Plates XXII.–XXVI.).

[Read 12th December, 1907.]

The highlands of Western Victoria form an area mostly occupied by ancient rocks between the north-western and south-western plains. The line of Division on these highlands between the north and south flowing streams is variously spoken of as the Main Divide or the Dividing Range; to the latter name the words "Main" and "Great" are often prefixed. These names are also applied to the rest of the main watershed line throughout the State.

The name Great Dividing Range had a very simple origin. In the days of early settlement exact description of localities was desirable, and the colony was divided into counties. For the most part the boundary lines of these counties are the streams, as being easily located natural boundaries; hence the main watershed became the boundary between the counties of the south slope and those of the north. This watershed is an actual fact on the land, usually easily located, though not always conspicuous. For the most part it forms a range in the popular sense of the word. It divides adjacent valleys, and from the fact that it forms the dividing line between a series of northern and a series of southern valleys, it easily became known as the Great Dividing Range. The first official use of the term was in connection with the definition of county boundaries,[1] purely as a descriptive term without reference to its varying character. But apart from any geological examination the early surveyors must have known that its aspect varied considerably, and that occasionally it required careful observation to exactly decide

1 N. S. Wales Government Gazette, 1848.

its position. The use of the term did not imply that it was a Mountain Range in an exact geological sense (the date of introduction of the term should be remembered), nor do geologists ever seem to have regarded it as such.

Rather strangely Professor Gregory[1] has described Mr. Reginald Murray as supporting the term, and connects with this supposed support its frequent use. Murray's "Geology and Physical Geography" was published in 1887, nearly forty years after the term had first been officially used. But we find on reference to the book that Murray does not use the term Great Dividing Range, but consistently speaks of the "Main Divide." Apparently his supposed support consisted in describing a main divide in Victoria running from east to west, whereas Brough Smyth[2] had previously described the principal dividing line as running south to Wilson's Promontory. But Selwyn[3] had already dealt with this idea, tracing it to Count Strzelecki in a map published in 1845.

Every objection which is urged against the Great Dividing Range can be used with at least equal force against this line to the Promontory. It does not conform to the arrangement of the ancient folded rocks; it is composed of residual ridges of denudation, and further it crosses the Mesozoic trough (a feature which cannot be paralleled on the Main Divide); so that on this southern line the continuity of any early high land area was soon interrupted. Brough Smyth himself uses the terms "Dividing Range" and "Great Dividing Range," and applies the shorter term even to the Mt. Ararat ridge far distant from his main dividing line, and subsequent to the date at which he had described the latter.[4]

On the geological map of Victoria the term Great Dividing Range appears, but its use is not due to Murray. He distinctly says[5] that "the latest Geological Sketch map is—with the addition of being geologically coloured—the topographical map issued from the Crown Lands Department." Even here the con-

1 The Geography of Victoria, 1903, p. 62.

2 Goldfields and Mineral Districts of Victoria, 1869.

3 Notes on the Physical Geography and Geology of Victoria, 1867.

4 Report of Progress of the Geological Survey of Victoria, II., 1874, p. 18; III., 1875, p. 17.

5 Op. cit., p. 3.

spicuousness of the Divide is largely due to the fact that in addition to the hill-shading there is the broken line used to denote the county boundary. The boundary is an actual fact in the configuration of the surface, but without the hill-shading would have been shown in the same way as the point-to-point lines which have to do duty as boundaries in some parts of the plains.[1]

North-west of Ballarat is a part of the range which Professor Gregory particularly criticises. He presents what is said to be an actual view of the country, and states that a number of persons would vary considerably in their location of the Divide at this point. I have put the question to a class of students on the road between Blowhard and Ascot, and though most of them were quite unacquainted with the place they had no difficulty in determining its position, and were all in agreement. I have, however, good information that the photograph reproduced in illustration was not taken on the Divide at all. Certainly it does not truly represent the character of the Divide at this point.

Enough has probably been said to show that Murray cannot be regarded as in any way responsible for the use of the term, and that its use and the prominence assigned to it by the Lands Department is not, from their point of view, unreasonable.

Professor Gregory goes further, and says that the Great Dividing Range is "a misleading geographical myth." We have seen that the Divide is certainly an actual fact; the name may be badly chosen, but it is ordinary current language, and makes no claim to be a scientific term. It does not seem to have misled many scientific investigators, though it may have been misleading in the teaching of geography by teachers with little scientific knowledge. Professor Gregory attacks the biological evidence. He depreciates the support of the biologists by hinting that it biassed and selects out of the mass of evidence, two items for his argument of disproof, the distribution of the eel and of the varieties of magpies. He says that he has heard from fishermen of eels being taken from the tributaries of the Murray; so have most people, but unfor-

1 See boundaries of the County of Ripon on the Geological Map of Victoria.

tunately for the argument the Murray eels turn out on investigation to be either lampreys or importations, though it is quite in accordance with the known habits of eels to wriggle across the Divide occasionally, as they can travel some distance on land during heavy rains. The magpie is scarcely worth consideration in this connection; it can fly across the Divide if it likes If one variety is northern and the other southern, there is nothing to keep either exactly in its place. In spite of anything that can be said, the fact remains that there is a greater difference between the plants and animals of northern and southern Victoria than there is between those of southern Victoria and Tasmania.[1] This is all the more remarkable when we consider the Divide closely. Differences in climate and soil have a large share in producing this result, but we can only explain its importance in this respect by considering it a Divide which has been much longer established than Bass' Strait.

There is little doubt, however, that Bass' Strait dates from within the human period in Victoria.[2]

The Main Divide, from a geographical point of view, is a watershed line of composite character between the north and south flowing streams. Biologically it is an area of highlands sufficient to offer some direct obstruction to the migration of plants and animals, and to establish a climatic difference which further affects their distribution. Commercially and industrially it is important, not only for this climatic difference, but because it is a sufficient barrier to have determined trade routes by its easiest passes. Politically it has become incorporated as a boundary line of districts in much of our administrative system.

I propose now to consider the character of the western highlands as a whole, then of the Divide as we now see it, then its origin and early history.

The rocks of the western highlands are for the most part coloured as Ordovician on the geological maps, though direct evidence of fossils has not yet been obtained over the greater

1 A. H. S. Lucas, "On some facts in the Geographical Distribution of Land and Freshwater Vertebrates in Victoria." Proc. Roy. Soc. Victoria, IX., new series, 1897.

2 A. W. Howitt, Australasian Association for the Advancement of Science, Sydney, 1898. Presidential Address, Section G.

part of the area. With these are associated granitic and metamorphic rocks and a few small patches of more basic igneous rocks. In the extreme west a considerable area of sandstones usually regarded as Upper Palaeozoic occurs, resting on the granitic, metamorphic and other old rocks. A few scattered patches of the Permo-carboniferous glacial series also occur, though these are absent from the greater part of the area.

The Mesozoic rocks we may regard as outside our present subject. The supposed occurrence of this series at Skipton requires further evidence before it can be accepted as definitely of this age.[1]

Overlying the older rocks on the highlands are fluviatile, lacustrine and volcanic rocks of Cainozoic age. On the margins of the highlands some of these beds may be litoral or estuarine. The fluviatile deposits are in some cases remnants, and then usually at a high level; in other cases they are well preserved continuous valley deposits, forming deep leads either above or below the present valley levels.

The present surface configuration is not determined by the folding of the older rocks. To quote Selwyn, "the strike of the older rocks constituting the mass of the main range is at right angles to the axis of the range itself, and quite uninfluenced by the granitic and other plutonic or basaltic rocks occasionally met with equally on the range as on either side of, and remote from, its axis."

From almost any eminence one of the first features of the landscape which attracts attention is the occurrence of long lines of nearly level-topped or undulating ridges. Occasionally these ridges may abruptly end or be continued at a lower level. Here and there an isolated volcanic hill rises, or it may be a group of such hills, and more rarely there are solitary hills and ranges of other appearance. The general character is that of a plateau which has been deeply trenched by a series of valleys. Between these valleys are the residual ridges, the remnants of the old high plain.

If we imagine the high plain restored following the line of the present nearly level hill crests, we would have a plain

1 R. A. F. Murray, Report on the Skipton Coal Seams. Report of Progress Geol. Surv. Victoria, VII., 188

often with an appreciable slope and with marked difference of level at different parts. Abrupt inequalities would be found at places, as, for instance, on the east face of the Grampians, the south face of the Pyrenees, and to the south-west of Bacchus Marsh. In other cases the fall would be gradual as from Daylesford south-westerly. We must bear in mind, however, that it is possible for a long gradual slope of the summits to be a result of denudation of a once level surface; as the lower parts of the valleys are likely to be deeper and wider, the ridges between them, if narrow, may be reduced in height.

The plain clearly does not conform to the folds of the underlying rocks, and is a plain due to excavation, not accumulation of material. As the superficial deposits of the plain are of terrestrial origin we may regard the plain as due to subaerial denudation, and as representing a peneplain formed by long continued erosion.

Possibly a few low ridges older than the peneplain may still be recognised. The present highest point in Western Victoria is Mt. William, 3827 feet above sea level; Mt. Buangor in the Pyrenees reaches 3247. Mt. Buangor is, however, simply a part of the sloping plateau stretching far to the north. If it were part of an older peneplain we would expect more advanced dissection of the mass, whereas the steep valleys of the south slope of the Pyrenees are clearly of no great antiquity. Also if Mt. William and the accompanying ridges had existed before the peneplain was established, we would expect them to be either more dissected, or that we would find marine deposits extending into their deep valleys. Both of these are best regarded as most elevated parts of the peneplain itself. The peak of Mt. Ararat is in the hard contact rocks adjacent to the granitic rock, and with the present small width of the ridge would naturally result from denudation of a late date, and still in progress.

The granitic hills of Mts. Beckworth, Bolton and Misery appear to be possible peaks rising above the peneplain; the highest points of the first two of these, at whatever date established, are due to the resistant character of a fine grained granite poor in mica. Their relation to the general level of the peneplain is obscured by the extensive basaltic covering on both

sides of them. Most probably they stand above it. Mt. Doran stands up well above the level of a flat ledge on its east side. On this ledge are the Lal Lal iron ores, but recent deep valleys running down to the Moorabool have reduced both ledge and iron ores to a series of fragments. Probably the ledge represents the peneplain level. Mt. Egerton may be similar to Mt. Doran.

The great volcanic plains are subsequent to the elevation and partial dissection of the peneplain.

As to age, it appears most reasonable to assign the peneplain to the long continued Mesozoic denudation reaching its final condition at the commencement of the Cainozoic. The oldest of the fluviatile deposits on its surface, commonly called the oldest gold drift, afford no fossils, but on field evidence both on the Moorabool and at Stawell, they are to be regarded as equivalents of some part of the Barwonian series in the marine beds, and probably of its lower part.[1]

The older volcanic Rocks in many parts of Eastern Victoria bury lacustrine deposits with fossils of early Tertiary age. The Older Volcanic has been shown to be Barwonian by Messrs. Hall and Pritchard,[2] and it appears to occupy in some cases positions which are practically level with the peneplain as if it had flowed in and filled the earliest valleys of the first stages of elevation.

The elevation which stopped the formation of the peneplain and introduced a new period of deep valleys, may not have been simultaneous in all parts of Victoria, nor was it without interruption as is seen by the advance of the marine deposits over fluviatile at the Welcome Rush, Stawell,[3] and by oscillations of level proved in the marine tertiaries.

The folding of the old sediments and their invasion by the granitic rocks had long ceased before the formation of the peneplain. But unequal movements were no doubt still in progress through the Mesozoic period. The Mesozoic rocks occur in defi-

1 N. Taylor, Report on the Stawell Goldfield. Progress Report Geol. Surv. Vic., II. and III.

2 Hall and Pritchard, "The Older Tertiaries of Maude, etc." Proc. Roy. Soc. Victoria, VII., New Series, 1895.

3 N. Taylor, loc. cit.

nite areas to the south; they probably have never extended across the present highlands. If the surface had been made almost flat the appearance of granites on the peneplain would be simply a question of the level reached by the granites. This would depend partly on the level it originally reached at the time of its intrusion, and partly on later movements, which it might share with adjacent sediments. The granitic rocks of Victoria do not as a rule appear in well marked axial lines, but in places they show very straight boundaries on the peneplain; the south edge of the Mt. Cole granite in the Pyrenees is an example, though on the map the straight boundary is obscured by the accumulation of detritus at the mouth of a short valley. A fault had probably already existed while the peneplain was forming, and the more elevated granite to the north had been exposed by denudation. On its northern boundary this granitic area meets the sedimentary and metamorphic rocks on irregular lines. A similar explanation might be given of many other granitic boundaries in Victoria. Selwyn had already in 1857 referred to a fault line on the east coast of Port Phillip, making the boundary of the granitic areas there.[1]

We have not only to consider in connection with the positions occupied by granites, the height to which they were brought at the time of their intrusion, but also the subsequent movements as inert masses. In the formation of the peneplain it is evident that a point of maximum elevation is a point of maximum denudation, and consequent more probable exposure of deep seated rocks. On the other hand the downthrow side of a fault is, other things being equal, a point favourable for the preservation of the newer and more superficial deposits. This may have been the reason of the survival of a small glacial area at the Midas mines[2] north of Ballarat. Messrs. Officer and Hogg[3] have also described the glacial rocks as terminating north of Coimaidai at a steep bank of Ordovician rocks, and though they regard it as a pre-existent valley wall, it seems to me that

1 See Hall and Pritchard. Some Sections Illustrating the Geological Structure of the Country about Mornington. Proc. Roy. Soc. Victoria, XIV., pt. I., New Series.

2 E. J. Dunn, Notes on the Glacial Conglomerate, Wild Duck Creek, Department of Mines, Melbourne, 1892.

3 Proc. Roy. Soc. Victoria, X., pt. II., New Series, 1898.

it may also be a fault line, north of which the glacial beds are lost by denudation.

Before considering the history of the elevation and dissection of the peneplain, we may look further at the present condition of the highlands.

On the whole the valleys run to north and south, though there are some peculiar exceptions, especially in the head waters of the Loddon and the Wimmera, and the course of the water from the north of Ballarat to the Hopkins. Going westward from Ballarat by rail it is apparent that the present surface is occupied by a number of north and south ridges and intervening valleys, and a wider acquaintance with the district not only confirms this view, but shows that the north flowing and the south flowing stream at places seem to occupy the two ends of one great valley.

Taking them in order from the west there is a great valley between the Grampians and the Mt. Ararat Range. This drains north by the Little Wimmera or Mt. William Creek and south into the Hopkins; there is no perceptible Divide for some distance in the floor of the valley. On the map the county boundary takes a straight line from the spur of Mt. William to a spur of Mt. Ararat. This is not part of the line marked as the Great Dividing Range; it stops on the spur from Mt. Ararat. The Mt. Ararat Range runs nearly north and south and is continuous (with a slight irregularity in its line) with the Black Range south of Stawell. West of this range is another valley. The railway rises up its south end, crosses to the north fall at an elevation of 1070 feet above sea level, and follows down the valley of the Concongella Creek to Stawell. In view of the barrier presented by the long Mt. Ararat range on the west, this will probably long remain the chief entrance to north-western Victoria.

By the next valley the Ararat-Avoca railway passes to the north of the Divide, crossing it in a gap at an elevation of 1104 feet; it thus enters the valley of the Upper Wimmera, and follows it up eastward through the Pyrenees to Mt. Direction, where by another pass at an elevation of 1214 feet it enters the Glenlogie valley and thence to the Avoca.

One of the most remarkable of these meridional valleys lies between Larne-Gerin and Mt. Buangor. To the north the Mt. Cole Creek runs down to the Wimmera. But as one stands on Ben Nevis, some miles to the north of the Divide, there is an uninterrupted view down the valleys of Middle Creek and Fiery Creek into the south-western plains. The Divide in this valley needs looking for. Standing on Ben Nevis more than a thousand feet above it, it sinks into insignificance. From Mt. Cole looking south similar meridional valleys and ridges are seen on the lower country The Larne-Gerin range continues south of the railway line, and is sufficiently important to cause the road and railway to run to the same low notch close up to Larne-Gerin.

East of the Mt. Cole Ranges the same north and south ridges continue, but with less elevations. The road from Chute to Lexton crosses a low Divide, but is flanked on either side by more prominent ridges. In fact this portion of the Divide, from the heads of the Glenelg to the heads of Trawalla Creek, is composed of two differing constituents. It is high where it crosses the meridional ridges or continues along them for some distance; it is usually low where it crosses the intervening valleys. As the head of each valley is to some extent independent of the next one, the Divide sometimes acquires a distinctly angular character, most marked in the rectangular portion at the head of Mt. Cole Creek.

But a short distance to the south-east of Lexton the character of the Divide changes. The old rocks disappear, and, instead, the summit of the watershed is composed of Volcanic rocks. Out of a great area of volcanic rocks there stand up the peaks of Mt. Misery. Bolton and Beckworth, none of them actually on the present Divide, but forming the highest points of a meridional ridge buried by the volcanic rocks. If these rocks are supposed removed we would have two more great valleys. We may call the western one, from the parish name, the Ercildoun Gap, and the eastern, similarly, the Ascot Gap. The latter is the lower, and even with its extensive lava streams and volcanic hills is still the easiest and lowest level pass across the Divide between Kilmore and the neighbourhood of Ararat. Here four main roads and two railways cross the Divide from Ballarat, and

the situation of Ballarat is at the entrance to a large area of north-central Victoria just as Ararat stands at the gate of the north-west.

Further east the Divide is again composed of Ordovician Ranges, but the meridional ridges are prominent even in them in spite of the existence of the west flowing heads of the Burrumbeet and Yarrowee Creeks. From west of Creswick a ridge runs south to far beyond Buninyong. The complete infilling of the valley on its east side by basalts has diverted waters across this ridge into the Yarrowee, but this is clearly a late modification. In this eastern valley the Divide is again buried under basalts in what we may call the Dean Gap. The area south of this is commonly known in Ballarat as the Eastern Plateau. Mt. Warrenheip stands on it, but contributes very little to it. The plateau lavas are from the north near the hills on the present Divide, and its surface falls with an unbroken slope past the east side of Warrenheip. Further east the Divide follows Ordovician rocks with gradually rising levels to the vicinity of Daylesford.

I have attempted to illustrate these features of the Divide by the accompanying plans and sketches. On the general plan of the Divide I have indicated some of the north and south ridges. I have had to compile this from various sources. Two early maps of Ripon County issued by the Lands Department both note the absence of a distinct ridge west of Mt. Ararat. One of these marks the ridge south of Larne-Gerin, and states that it was noticed by Mitchell. From these maps also I have obtained the position of the volcanic hills in the Ercildoun Gap. I have obtained other information from the Geological maps of Ararat and of Learmonth. The view taken from the summit of Mt. Buninyong shows the south ends of a succession of ridges and the intervening valleys. The line of sight to Larne-Gerin crosses the Divide so that the slope of that hill facing the observer drains north by Mt. Cole Creek.

The view from Mt. Blowhard shows the series of Volcanic hills which form the Divide in the Ascot Gap. The broken line round the base of each hill on the map shows the approximate extent of the slope from that hill. The Divide is formed by the coalescence of the bases of the volcanic hills, and hence

may be at any height which was sufficient to turn the waters of the adjacent valley. Thus the drainage of the south slope of the Mt. Bolton Range is diverted northward. A Divide is obtained which, though usually quite distinct, is yet at a low level, and we have a remarkable feature of the levels of the Waubra Railway that it is everywhere at a higher level than close to the Divide, falling from 1508 feet at Waubra Junction to 1350 at Learmonth, then crossing the Divide at about 1360 and ascending a valley to Waubra. There are several swamps close to the Divide where the slopes of the volcanic hills meet. Lake Learmonth only differs from these swamps in being larger and practically permanent, which has been helped by building up its outlet and bringing in water across the Divide.

Beneath the extensive volcanic area both north-west and north-east of Ballarat there is still some uncertainty as to the courses of the old Divide and of the old valleys. We may safely say that the whole area which now drains north also drained north before the lava flows. In the Ercildoun Gap is a lead falling north; in the Ascot Gap another lead also falling to the north, and a north falling lead exists not far north of the present Divide at Dean. But south of the Divide there are three areas which present difficulties, the Burrumbeet Basin, the western leads of Ballarat and the Haddon leads, and the area about Warrenheip and Bungaree. Investigations have usually proceeded on the assumption of the non-disturbance of relative levels at different points, but we have sufficient evidence that this is not absolutely safe. We must take account of local disturbances[1] and of unequal movements affecting large areas, as will be shown below.

The question is further complicated by changes of the flow of streams by the ordinary process of river capture, and by the fact that various lava streams which have altered the flow or influenced it are not absolutely, and sometimes not approximately, contemporaneous even within the one drainage area. By this means a great change might be produced in one part of a valley while another part of the same valley was unaffected.

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1 Notes on the Stony Creek Basin, Daylesford, and references there. Proc. Roy. Soc. Victoria, XVII., pt. II., New Series.

From Smythesdale certainly a lead was worked with a fall northward under the present south flowing Smythe's Creek. The alteration was probably due to the lava streams. From near Staffordshire Reef a large valley falls to the north to join the Yarrowee Creek, and its waters are turned south again down that creek. The Yarrowee valley itself west and south of Buninyong, and the old Durham Lead which preceded it, are comparatively narrow. The Lal Lal Basin cannot have drained south at the west end of Mt. Doran. We find thus a considerable east and west Divide many miles south of the present Divide. (Such a Divide is mentioned without the evidence being quoted in Professor Gregory's Geography. It can, however, scarcely turn to the north-east as shown in the figure there.) At Smythesdale it has long been recognised.

It must not be assumed that this was a Main Divide from which the streams flowed north to the Murray. North of Mt. Doran we find an outlet to the east. Alluvial sands just show below the basalt at the foot of the Lal Lal Falls. Half a mile east, just below the little falls of the Western Moorabool, the basalt for a short distance comes down to the bed of the river. On a creek a little further east a considerable width of sands is exposed and not bottomed. On the Eastern Moorabool at Bungeeltap, they are much wider, and show also in some of the creeks in the parish of Bungal. Thence the volcanic plain is unbroken till we reach the Parwan valley, where the estuarine beds appear and are well exposed as far as the steep descent on the Rowsley fault. There is little doubt that this is the original outlet from the Lal Lal Basin. (The actual area of the brown coal at Lal Lal may be regarded as a local subsidence.) This eastward valley could scarcely have drained any appreciable area west of Mt. Buninyong. It received, no doubt, a part of the drainage of the country buried under the southern edge of the Eastern Plateau. Further north a part of the area north of Warrenheip may have discharged its waters past Gordon and thence also to the Parwan Estuary.

To return to the lead at Smythesdale. The main Trunk Lead has been worked for some distance north, but not far enough to leave its final course without doubt. From the Ballarat Common westward, the railway follows down the gentle slope of a lava

stream to the Burrumbeet Creek. Beneath it is a valley into which the Trunk Lead flows, but opinions have been divided as to whether the outlet of this valley is towards Burrumbeet or in the opposite direction, and thence to the Ascot Gap. If the fall is into the Burrumbeet Basin, we are still in doubt as to the outlet from that Basin. Parts of that area may drain northward by the Ercildoun Gap, north-east to the Ascot Gap or south-west by a route near the present outlet.

The western leads of Ballarat are subject to the same uncertainty as the Trunk lead. But even with regard to the Golden Point Gutter itself there is still some diversity of opinion. Close to the south limit of Ballarat City a point is reached at which there is a broad lead to the west, and a comparatively narrow lead to the south. Both have been worked. The question as to which was the real outlet of the stream above was discussed by Murray,[1] and he decided for the southern—that is, that the lead followed the same valley as the present Yarrowee. But the decision was based on small differences of levels. Either way the average gradient for some distance is much less than in the lead upstream. Against the southern outlet are the change in width and perhaps some minor features of the lead itself, the narrow valley of the Yarrowee downstream and the decided north fall from near Staffordshire Reef. Recent bores[2] show that an outlet is possible to the west. There is thus a double uncertainty in the course of the old valley, both as to the direction the waters took at Ballarat and as to the subsequent course of the Western Leads. Probably at Ballarat both outlets have been used, the head waters of the lead having been captured and diverted.

The present drainage system at Ballarat is determined largely by the volcanic centres. From the Ballarat Common extensive flows of lava have run to north, south, and west. Murray considered, from the records of the rock passed through in the Bonshaw shaft, that the uppermost lava stream or "first rock" is here missing. This shaft is in a valley at the south end of Sebastopol. In the present condition of the creek, the second rock, much decomposed on its surface, is seen exposed under

1 Report of Progress Geol. Surv. Vic., I.

2 Annual Report, Mines Department, Victoria, 1892.

the first rock. The first rock is missing from the shaft, but it continues on the opposite side of the little creek, and is traceable to the south end of the Buninyong Estate.

There is no reason to regard Lake Wendouree as a crater; it is only a shallow depression on the edge of the lava stream. But the source of the Ballarat "first rock" at least must be placed on the Common close to Wendouree. There is no cone of volcanic fragments; explosive action appears to have been of little magnitude at the emission of this lava. This is the present limit of the waters received by the Yarrowee; the north slope of the Common drains to the Burrumbeet Creek. The barrier of volcanic hills in the Ascot Gap quite prevents a northern outlet, and the Burrumbeet Creek is forced to flow west, and eventually to the Hopkins, though ordinarily the waters do not pass Lake Burrumbeet.

The original drainage of the elevating peneplain was then probably as follows:—In the western part one principal east and west crest divided a north and a south fall, but in the neighbourhood of Ballarat there was another important crest further south. It is not demonstrated, however, that any part of this formed a Main Divide, from which the waters flowed north to the Murray. In its western part it is uncertain, but in the eastern part the Parwan Estuary lay between the southern crest and a crest near the present Divide. Much of the waters from the north would formerly reach the Parwan, but they have been diverted by the volcanic barrier of Mts. Ingliston, Darriwill, Gorong, and an unnamed centre near Ballan. This has caused the formation of the present rugged Werribee Gorge in the old rocks, contrasting strongly with the smooth outlines of the Parwan valley in its soft materials. Further north there may have been an east and west ridge at Tarrengower.

Various suggestions have been made as to the possible origin of the Divide or of these parallel crests. Selwyn suggests "that the first outline of the existing main watershed was determined by some slight and almost accidental undulation, that may either have pre-existed on the old sea bed, or been produced during one of the earliest broad and equable upheavals, that resulted in a dry land surface." Professor Gregory regards it as connected with the intrusion of a series of granitic masses forming a Pri-

mitive Mountain Chain. Apparently this is regarded as Devonian in age. Mr. T. S. Hall[1] has ascribed it to cross folding connected with the pitch commonly observed in the folds of the older rocks.

I think it can be shown that any feature produced prior to the development of the peneplain must be of minor importance in determining the position of the Main Divide.

The gradient of the streams which formed the peneplain must have been very slight by the time that operation was finished. Without taking the estimated grade as low as 1 in 50,000,[2] we may say that if as low as 3 feet to the mile (about the gradient of a large part of the Thames), it would be quite inadequate to account for even the more moderate inequalities of level of the peneplain. Some other cause has established far greater differences of elevation than those of the peneplain as formed, and this cause must have operated subsequent to the formation of the peneplain. At Warrenheip the peneplain level is about 1750 feet above the sea level. Thirty miles to the south are contemporaneous marine beds which even allowing for depth of water may be stated as elevated less than 700 feet. This gives a difference in elevation equal to 1000 feet in 30 miles. From the south-west of Daylesford to Warrenheip the general level of the peneplain falls from about 2350 to 1750, or about 30 feet to the mile. These would give slopes quite sufficient to overcome the slopes of the original peneplain, though it would not necessarily reverse the original slope in the vicinity of a ridge. And it must be remembered that the ridge remaining on the peneplain would only be a very much modified remnant of an older eminence.

The more marked differences of elevation about the Grampians and Pyrenees would be correspondingly more effective in overcoming older inequalities.

Selwyn's suggestion leaves the question very open if we substitute peneplain for original sea bottom. Professor Gregory's Primitive Chain, if it existed, would have been reduced to insignificance in the formation of the peneplain, but there are great difficulties in supposing its existence. In the first

1 Victorian Year Book, 1905-6.

2 Gregory, op cit., p. 78.

place our granitic rocks do not, as a rule, present the character of axes of even small mountain masses. The dip and strike of adjacent rocks are little affected by them (except perhaps as will be noticed below). He states[1] that the Warrenheip granite affects the direction of the beds at Ballarat, but he has stated the direction of the granite boundary wrongly, and missed the abundant evidence of folding. His argument on this point at Ballarat completely fails on examination. It is far more probable that most of our granitic intrusions were introduced by a "stoping" process with foundering and absorption of the adjacent rock overhead. In addition a Primitive Divide as early as the granitic intrusions does not provide for the southern origin of the glacial series.[2]

With regard to Mr. T. S. Hall's suggestion, we require a good deal more evidence on the matter of pitch, particularly as to the extent to which it is persistent, and how it varies from place to place. It may be supposed to originate in many ways, and may be consistent or inconsistent in neighbouring folds. It is liable to be inconsistent if it is due to the making and dying away of individual folds, or if due to local disturbance as by a fault affecting a small area. Besides these it is possible that pitch may originate by varying intensity of the folding from place to place, so that the fold is sharper at one place than at another, and is curved in its strike. Or it may be due to the fact that compression in a solid produces a tendency to expand in a direction at right angles to the pressure, and this, if prevented, may give rise to a simultaneous transverse folding. Or it may be due to subsequent crossfolding. Or to the settlement of an imperfectly supported area over an invading granite. Or finally to the tilting of folded blocks the folds themselves being inert.

Settlement on an invading granite might be suggested in the case of the southward pitch from Bendigo, and the northward pitch from Keilor. But there are other cases which cannot be so explained. Mr. W. Baragwanath, jun., has called my attention to the pitch at Ballarat East, northerly at Black Hill, and southerly at Magpie Gully, and neither of them near granite.

1 Memoirs Geol. Survey, Vic., No. 4, 1907.
2 Officer and Hogg, loc. cit.

Pitch certainly influences details of hill and cliff shapes especially when combined with steep dip joints at right angles to the pitch. Examples of this are found at the Werribee Gorge and at Bendigo.

If crossfolding determined the original crests of the elevating plain, it must have been a cross folding produced concurrently with the elevation, and I think the pitch of our older folded rocks will as a rule be better explained by some cause nearly or quite contemporaneous with the main folding.

The clue to the cause of the early Divide on the elevating plain is to be found in the movements of elevating and tilting fault blocks.

The most conspicuous feature of the southern limit of the Victorian highlands is that they terminate at a practically straight line. The restoration on the latest geological map of Victoria of the granitic areas near Mt. Elephant makes this still more evident. It must be remembered that the volcanic area north of these granitic inliers is gradually rising to the north and though not very high at the foot of Mt. Elephant it rises gradually and continuously to the Divide in the Ercildoun Gap. Similarly in Eastern Victoria two straight lines terminate the main mass of the highlands. These lines are independent of the rock folding, cross various rocks, and are no doubt fault lines forming the north limit of a relatively depressed area. Movement on these lines, or near them may have been both pre-tertiary and later. Consequently the comparison of levels on the north and south of these lines does not give a safe estimate of the amount of tilting, apart from dislocation, of the peneplain, if such peneplain be regarded as continuing beneath the tertiary areas, or merging in a plain of marine denudation.

It is likely, but not altogether certain, that similar movements had already formed the Mesozoic trough. In Western Victoria it is largely a question of what Mesozoic rocks are buried under the tertiary—a point which has not yet been investigated.

At the east edge of the Ballarat Plateau we have the wall at Bacchus Marsh. This does not coincide with the bank of Ordovician rocks against which the glacial rocks rest. Even the importance of that bank may be exaggerated; it must be kept

in mind that remnants of the glacial series are also found west of it.

A note to Daintree and Wilkinson's map of 1866 ($\frac{1}{4}$-sheet 12NE), states that the basalts seem to have flowed over a steep declivity, and further north the accompanying section shows inclined beds of the early tertiary rocks. These comparatively steep beds are in contact with a mass of intrusive older volcanic rocks, and I had the impression formerly that the inclination was regarded as an effect of the basaltic intrusion, but I do not find it described as such. West of the disturbed portion the tertiaries continue at higher levels and horizontal, and a better explanation is that at this point on the north side of the Werribee there is a monocline probably faulted and further south along the edge of the high basaltic plateau, a fault scarp over which the lavas have flowed. It continues further south still with a curve a little to the west, and the quarter-sheet 12SE to the south shows the Ordovician rocks terminated a straight line which is also the edge of the higher land to the west. Down this a number of short steep valleys flow. The aspect of the locality as seen from any point of vantage to the north agrees with this. As the line of fault passes between the old township of Rowsley and the railway station of the same name I would call it the Rowsley fault.

On the east or depressed side the surface of the plain below is overspread with detrital material. This evidently is material carried by the streams down their steep courses from the highland, but which they could not transport across the plain. The Parwan Creek has cut its valley down to the base of the present wall, but with its slighter fall it has not cut through the basalt on the lower country. Its level is here temporarily kept up, and it has attained a gentle slope in its bed above the obstacle, and being in soft material of the old estuary has long gentle slopes on the sides of the valley, rising gradually to a basaltic escarpment, which is sometimes over a mile from the main waterway. Below the escarpment the slopes are strewn with broken basalt from the plateau edge, undermined by the working away of the soft sands below, but unable to travel down the long gentle slopes. The head of the Parwan tributary near Ingliston station shows an earlier stage in the development of

such a valley, full of angular blocks from the basalt, and with its sides for some distance an almost continuous series of landslips. A similar explanation can be applied to Bacchus Marsh itself. At the Marsh the valley has been cut through the basalt to the underlying tertiaries. Down stream deepening is less rapid because the hard rocks extend to lower levels and are not yet penetrated. Hence the valley has been greatly widened in the soft rocks. When the Parwan has cut through the couple of miles of basalt in its course between its upper valley and the Marsh, it will be able to deepen its upper valley again at a more rapid rate and perhaps even to recapture what it has lost to make the Eastern Moorabool.

Professor Gregory has described the Grampians as ranges of the Pennine type. The area of Upper Palaeozoic rocks forms a great syncline with a few minor corrugations. The long gentle slopes towards the syncline are near the direction of the bedding, and the short steep slopes in their present form seem largely due to strong jointing. A well-developed jointing also occurs in a direction at right angles to the ranges contributing to the jagged character of their summits. Selwyn shows a section of the south end, and Krause[1] has given a section near the north end. The latter shows one of the minor folds. He also shows the granitic rocks as intrusive, though in his description he regards this point as doubtful. Two causes may have led to his favouring the idea that the granodiorite was intrusive. In the area afterwards worked for gold at Mt. William sandstone from the high hills close by is common. In its natural condition it would be difficult to see that this area was granodiorite covered with a thin layer of debris from the hills, and he seems to have mapped it as sandstone with dykes. Also there are undoubted dykes in the sandstone. Those with which I am acquainted at Hall's Gap are more probably allied to the Coleraine trachyte than to the granitic rocks.

The strike of the Grampians sandstone varies considerably, being distinctly west of north in the northern parts, but more meridional or east of north in the vicinity of Mr. William. The dips are usually low, but near Hall's Gap Krause records 77 deg.,

1 Progress Report, Geol. Surv., Vic. I.

and I have observed 60 degrees, both on the outer range. A dip of 51 degrees is shown on Stony Creek by Krause.

The greatest elevation is at Mt. William, in the centre of the eastern ranges.

Neither of the earlier sections show any faulting, though the descriptions in both cases give estimates of thickness which are quite inadequate, apart from faulting. The main faults have not been observed, and I have no definite information to assign them a probable inclination. I have observed a nearly vertical strike fault in Stony Creek, near Hall's Gap. There is, however, little doubt that the great valleys here are determined primarily by faults allowing a succession of parallel ranges to be formed of the same beds, and it is probable also that many other parallel faults occur allowing repetition of beds in the long gentle slopes of the hill towards the syncline. The average inclination of these slopes is much more gentle than the dip, though in a hill south of the junction of Fyan's and Stony Creeks at Hall's Gap it is possible to walk a long distance down the bare rock following the bedding plains.

A feature of Fyan's Creek valley, which indicates late movement on this fault, is the form of some of the tributary valleys. At the Silver Band fall the stream comes out from a gap in the east face of the range and drops into the valley below.

We may ascribe the Grampians to the unequal elevation and tilting of a number of fault blocks, in which the principal faults were approximately meridional. The syncline was probably pre-existent and sandstones already somewhat denuded, forming a part of the peneplain, so that they already were reduced in thickness on their eastern edge. Another fault may exist under the Mt. William Creek valley outside the ranges, and the whole series may be associated with similar faults determining the west end of the high lands as a whole. The faults need not necessarily be altogether of late date; all that is requisite is movement subsequent to the peneplain formation, it may be on old faults, and only on some of these.

We may extend this idea of block elevation to the rest of the highlands. A striking example is seen in a side view of the Pyrenees. Such a view is obtained from many points; that from Maiden Hill at Waubra is particularly good. At the south end

the ranges drop suddenly to the lower country about Beaufort. There is no doubt that this southern end of the Mt. Cole Ranges is a fault scarp, and forms the south end of a great tilted block. It is also probably a fault line of early date on which movement has been renewed, as the granite is apparently absent from the peneplain below. The south end is deeply scarred with short steep valleys (not visible from this point), and the edge of the granite is in part buried under the talus fans. Northward the ranges present a long even slope. Buangor is 3247 feet above sea level; Ben Nevis, 2875; Avoca Hill, 2464; and Landsborough Hill, 1903. The Avoca River runs north down the east side of the highest ranges. Further north the Richardson and the Avon drain the north end of the block. The summits of the Pyrenees are to be regarded as the same peneplain as at Ballarat, but elevated more than 1000 feet higher. The parallel range of Ben Major and Ben More is on this side the Avoca River between it and the Bet Bet Creek. Possibly the Avoca follows down an east boundary fault, for the Ben Major range is much lower, and the levels fall still more to the east under the lava filled valleys.

There is one great interruption to the regular slope of the line of the Pyrenees summits. Behind Lexton we look into a great gap in the mass; in the gap is the pointed summit of the Sugarloaf, and beyond is the shoulder of Ben Nevis. We look down the valley of the Upper Wimmera. Two explanations are possible. There may have been an original slight hollow produced in the elevation of the block or a change of slope. The small difference in height between Ben Nevis and Avoca Hill seems to favour this as well as the extent of country whose drainage is diverted west and the fact that the diversion is not very new. As an alternative it may be simply a case of river capture, perhaps helped by an original steep fall at a fault on the west of the block. Some amount of capture from the Richardson and Avon has probably taken place, but an original inequality of elevation very likely started this course of the Wimmera.

The Pyrenees may be taken as representing a range, due to the same causes as ordinarily produce the Pennine type, but with a gentle or slightly undulating long slope and now much modified by denudation. It is evident that in such a series of eleva-

tions and tilting there may be more than one east and west crest produced. This would explain the character of the drainage system initiated in the Ballarat area, Mt. Doran, if previously formed, helping somewhat to constitute the southern crest. From the high land before mentioned running from east of Creswick to beyond Buninyong there seems to be a general fall to the west. Much of this may be due to the later denudation, but it is not unlikely that a fault exists under the Ascot Gap or at least a line of an original minimum elevation. A fault might have contributed to the preservation of the small patch of glacial rocks known to exist at the Midas Mines.

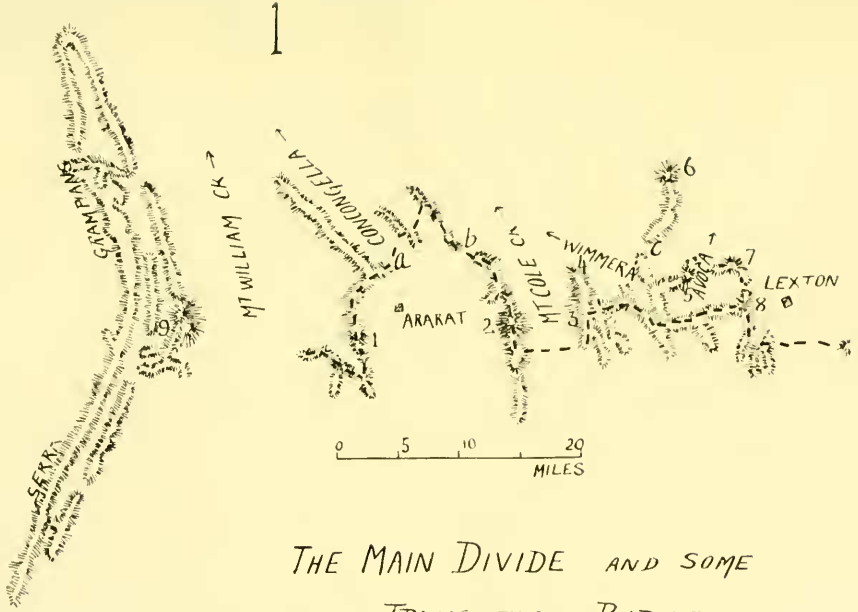
That east and west crests would be at first produced might be expected from the general trend of the Mesozoic trough, the tertiary trough and Bass Strait, all of which may be regarded as a series indicating a prominence of movements on east and west fractures since the time at which the active folding of the older rocks ceased.

Some of the faults suggested may seem to have little to support them, but I think there is sufficient evidence to sum up the character of our western highland and Divide as due to unequal block elevations of a Mesozoic or early Tertiary peneplain, with subsequent extensive modification by denudation and volcanic activity.

DESCRIPTION OF PLATES XXII.–XXVI.

Fig. 1. The Main Divide and some of the transverse ridges, from near Lexton westwards, compiled from various sources. The names of the principal north flowing streams are shown. The south slope, except close to the Serra Range, drains eventually to the Hopkins. The numbers indicate hills as follows:—1, Mt. Ararat; 2, Larne Gerin; 3, Mt. Buangor; 4, Ben Nevis; 5, Sugarloaf; 6, Avoca Hill; 7, Ben More; 8, Ben Major; 9, Mt. William. *a* is the gap by which the railway goes from Ararat to Stawell; at *b* the Ararat-Avoca railway crosses the Divide; and at *c* passes from the Wimmera to the Avoca valley. The Main Divide is indicated by a broken line.

Fig. 2. Hills on and near the Divide at the Ercildoun and Ascot Gaps. O indicates Ordovician and G granitic areas. The full



THE MAIN DIVIDE AND SOME TRANSVERSE RIDGES

FROM NEAR LEXTON WESTWARD

Proc. R.S. Victoria, 1907. Plate XXII.